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RELATIVE GROWTH OF THE EYE*

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That there is a close relation between the axial diameter of the eye and the refractive state is well known, but it has been hotly debated whether the commonly observed increase of myopia during childhood is due to an active growth or a passive "stretching" of the globe during this period. For this reason any information on the growth of the eye is to be welcomed. Data collected by Deller, O'Connor and Sorsby (1947) afford an opportunity for a limited but interesting analysis of growth. These authors present x-ray measurements of the three diameters, vertical, transverse, and axial or sagittal, for 43 individuals (37 male, 6 female) ranging from 15 to 77 years of age (two cases in which measurements were questioned by the authors have been omitted from this count). Two earlier papers contain data for younger ages. Collins (1890) measured the diameters of the globe and of the lens in 19 fetuses but unfortunately presented only five averages without the individual values. Weiss (1897) gave anatomical measurements of the three diameters of the globe in 25 eyes from 20 individuals (14 boys—in 5 cases both eyes were measured—4 girls, and 2 "children"). In addition the averages are given for 14 newborn and for 5 adults. There are thus available measurements of a full range of eye size, although, unfortunately, made by three observers and by two methods and less in number than could be desired for satisfactory statistical analysis.

Before attempting an analysis, it will be necessary, therefore, to examine the relations between the measurements by the two methods. Deller, O'Connor and Sorsby employed a roentgenological technic,

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which, since its introduction by Rushton (1938) has been so developed and tested as to be considered standard. It gives the distance between the light sensitive layers of the transverse or the vertical diameter and in the case of the axial the distance of the sensitive layer from the vertex of the cornea. The diameters given by Collins were made on eyes hardened in Müller's fluid, this is also true of Weiss, although he gives in addition the weights before hardening. If we take the measurements by the x-ray method as standard, the anatomical measurements are larger by twice the thickness of the sclera and the chorioid in the case of the equatorial diameters (or once for the axial diameter) and smaller by the amount of shrinkage due to fixation. These factors are difficult to balance. In the case of Weiss, where a comparison of fresh and fixed measurements are possible, the changes of volume on fixing range from 4 per cent increase to 22 per cent decrease, with an average of 4.4 per cent shrinkage in volume, or between 1 and 2 per cent in diameter. Lacking a more secure basis for correction, the original values were used; the plots show no marked heterogeneity from this cause.

RELATION OF SIZE TO AGE

As has been pointed out by Weiss and numerous other workers, the eye shows the early accelerated type of growth characteristic of the central nervous system. "While the body increases in volume 21-fold from birth to the adult stage, the eye increases only 3.25 times and the brain 3.75 times" (Duke-Elder, 1934, I, p. 368). For the first year the eye increases rapidly in size, by two years it has reached a diameter of about 20 mm, the minimum adult size; the maximum continues to increase, but by five years there are few cases in which the child eye

TABLE 1.

Relative Variability (C) of Eye and of certain Skeletal Structures

Source	Structure	C	
		Both Sexes	
Deller et al.	Eye, adult, vertical diameter	5.77	
	adult, transverse diameter	6.17	
	adult, axial diameter	8.63	
Weiss	Eye, new born, all diameters, estimate	4.7	
		Male	Female
Pearl	Skull, least breadth of forehead	4.29	4.55
	Height	4.21	3.96
	Length of base	4.07	4.11
	Greatest breadth	3.75	3.54
	Cross circumference	3.70	3.97
	Sagittal circumference	3.63	3.90
	Horizontal circumference	2.87	2.92
	Head, length	3.15	----
	Stature	3.99	3.83

could be distinguished from the adult by size alone. This point is further discussed in a later section.

VARIABILITY

The variability of the diameters of the eye is striking. For comparison with other structures of widely different size, the relative standard deviation or coefficient of variation (c-100 standard deviation/mean) has been used in Table 1. Values for the skull and height are from Pearl (1940). It will be seen that the variability of the newborn appears somewhat less than that of the adult but since the value is an estimate based on the ranges of the three diameters it cannot be given much weight.

The variability of the adult eye based on the 43 cases of Deller, O'Connor and Sorsby is interesting not only for the comparisons between the various diameters but also for the comparison of the eye with the measurements of the skull, which might be expected to show an intimate relationship to the eye.

The variability of the vertical is the least and of the axial diameter is the greatest; on the basis of the variance ratio the variability of the vertical does not differ significantly from that of the transverse diameter,

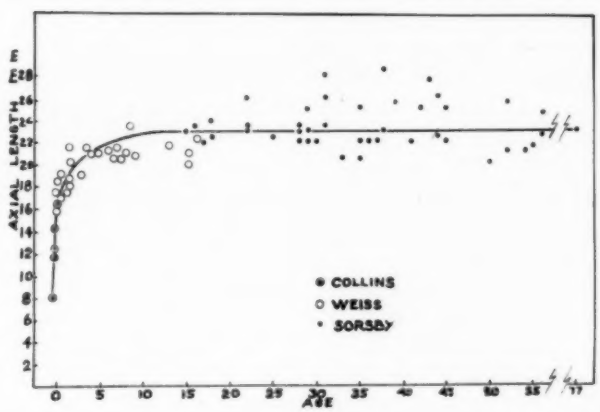

Fig. 1. Axial length on age. Plot of all individual records; line fitted by eye.

but the axial diameter is significantly more variable than either. This fact has a bearing on a point to be discussed later. From the table it will be noted that all diameters of the eye are more variable than the measurements of the skull, although by its type of growth the eye might be expected to show something of the close relation shown by

the skull and brain. Most of the differences in variability between the eye and the skeletal measurements are significant.

COMPARISON OF VERTICAL AND TRANSVERSE DIAMETERS

It is usually stated that of the two equatorial diameters, the vertical is the lesser, corresponding to the fact that the vertical radius of the cornea is less than the horizontal. Thus Duke-Elder (1934, I p. 33), gives the transverse as 24.13 mm. and the vertical as 23.48 mm., a difference of 0.65 mm. in favor of the transverse dimension. In the present series of 43 adult eyes the difference is in the same direction (transverse - vertical = 23.047 — 22.826 = 0.221 mm.) but the difference is very small and might have happened by sampling from a population in which no difference existed about once in every 50 trials. Perhaps this difference is the result of selection of the subjects, who include many emetropes and few astigmats. On the other hand, it may represent some peculiarity of the anatomical measurement of the globe as contrasted with the x-ray measurement of the position of the sensitive layer. Thus Weiss' external measurements of 5 adult eyes gives averages of 24.43 mm. for the transverse and 23.70 mm. for the vertical, a difference of 0.73 mm.

TABLE 2.

Correlation Coefficients for the Eye and for the Skull

Dimensions	Correlation coefficient
Eye diameters (Deller et al., n=43)	
Vertical and transverse	+0.90
Vertical and axial	+0.81
Transverse and axial	+0.59
Skull (Pearl)	
Brain weight and skull length	+0.55
Brain weight and skull breadth	+0.46
Internal length and breadth of skull	+0.41
Length and breadth of skull (male)	+0.40
Internal length and height of skull	+0.23
Length and breadth of skull (female)	+0.19

CORRELATION

There is a high correlation between the different diameters which, as might be expected, is in the positive sense in that large diameters are associated with large, and small with small. For the 43 cases of Deller, O'Connor and Sorsby the coefficients of correlation are given in Table 2 and Figure 3. It will be seen that the relation between the vertical and the transverse diameters is the closest. In fact 81 per cent of the variance of one is accounted for by the variability of the other, and only 19 per

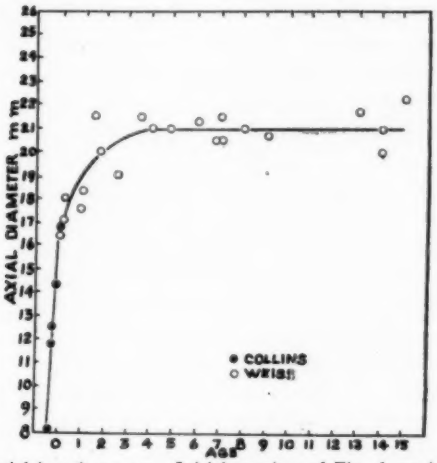

Fig. 2. Axial length on age. Initial portion of Fig. 1 on larger scale.

cent must be "explained" by other factors. The relations involving the axial diameter are both less close, especially that between the axial and the transverse diameters, in which only about one-third of the variance of one can be accounted for by the variance of its partner. These correlations are high as biological correlations go. For example, in a list of 145 coefficients of correlation for human anatomical or physiological data collected by Pearl (1940, p. 426), the present values would rank 5th, 16th, and 29th. Certain comparisons are of particular interest. The highest values in Pearl's list, ranging from +0.977 to +0.807 result from comparison of limb bones. Coefficients involving the skull are given in Table 2. It will be noted that all of these are lower than the lowest for the eye.

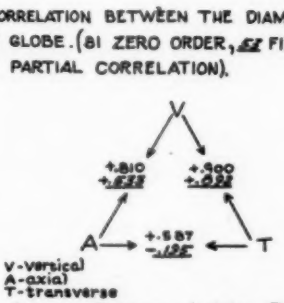

Fig. 3. Correlations between diameters of globe. Data from Deller, O'Connor and Sorsby.

ALLOMETRIC ANALYSIS

The measurements of Deller, O'Connor and Sorsby, of Collins, and of Weiss, covering a rather complete range of sizes, permit the application of the method of allometry or relative growth to the eye, apparently for the first time. (No full bibliography of allometry is here possible, many references will be found in Huxley, 1932, Teissier, 1934, and Richards and Kavanagh, 1945.) The simplest application of the method is to plot the logarithm of one dimension on the logarithm of a second, thus giving a graphic representation of relative sizes of the two dimensions. In many cases, the plot gives a straight line, showing that a constant ratio exists between the relative sizes. Since this ratio is interpreted as a ratio between the relative growth rates in which the identical ages are cancelled out, it is possible thus to get information concerning the relative growth rates from the sizes to which they have given rise. If a constant ratio is found, the formula may be calculated from the linear relation between the log values,

$$\log y = \log b + k \log x$$

in which y is a part plotted on a second part or on the whole x, log b is the intercept and k the slope of the line. In the arithmetical form this becomes

$$y = b\, x^k$$

Since the vertical diameter shows the highest correlation with both the other dimensions it has been chosen as a base and Figure 4 shows the 74 points based on 101 measurements from all sources of the transverse and the axial diameters plotted on this base, both scales being, of course, logarithmic. The simplest relation, in which the ratio is constant and is equal to unity is very closely realized by the plot of the transverse on the vertical diameters. The trend of the points is clearly linear and the slope is +0.94; the formula would therefore be

$$t = 1.059\, v^{0.94}$$

If the reverse relation, that is, the regression of the vertical on the transverse diameter, is calculated, the slope is found to be +1.00; the difference between the slopes proves not to be significant. The coefficient of correlation between these diameters is +0.98. As far as the available data indicate, the two equatorial diameters are growing at essentially the same rate.

When we consider the plot of the log of the axial diameter on the log of the vertical diameter, however, a quite different picture is presented. Instead of falling in a single clear line, the points show a less close and simple relation, best analyzed into three groups. Since in

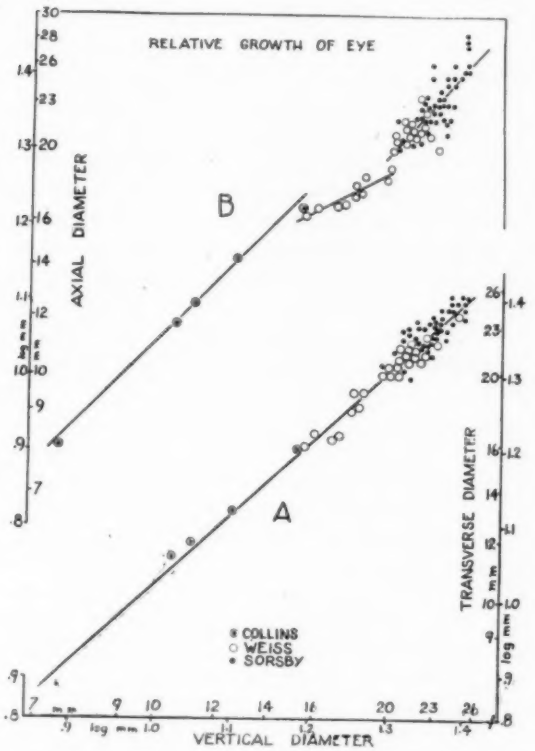

Fig. 4. Relative growth of the eye. See Tables 2 and 3 for constants.

biological data sharp discontinuities are the exception rather than the rule, the basis of these groups must be carefully considered. The three groups will be briefly characterized, their constants presented, and lastly the justification for their division considered.

Beginning with the smallest eyes (the lower left hand part of the the line) the first group includes the measurements by Collins of fetal eyes represented by the first five points. The last point, representing full term infants, is the average of three measurements, if the individual measurements were available it is possible that some might be assigned to the second group. The second group of ten points comes from Weiss' measurements of children; the first point represents an average of 14 new-born, some of which may belong to the first group, the remaining 9 are individual values. They include all children under one year,

and one at two and one-half years, but exclude one child at one and one-half and one at one and three-fourths years, and all three or over: the latter fall in the next group. The third group, representing the largest eyes, includes 59 points derived from the data of Weiss and from that of Deller, O'Connor and Sorsby. Although it shows greater dispersion than the corresponding portion of the regression of transverse on vertical diameter, as might be expected from the lower correlation found in the data of Deller et al., there is no evidence of any systematic difference between the data from these two sources.

The constants describing these three groups are presented in Tables 3 and 4.

TABLE 3.

Data for Figure 4, Graph of Relative Growth of Eye

	Axial on vertical diameter			Transverse on vertical diameter
Group	1	2	3	——
Source of data	Collins	Weiss	Weiss and Deller, et al	Collins, Weiss, Deller, et al
Number of				
points	5	10	59	74
individuals	19	23	59	101
Range of sizes				
vertical mm.	7.0 - 15.3	15.4 - 20	20 - 25	7.0 - 25.0
axial mm.	7.5 - 16.7	16.4 - 19	20 - 28	——
transverse mm.	——	——	——	7.8 - 25.5
Slope	+1.04	+0.52	+1.13	+0.94

TABLE 4

Regression equations for the fitted lines of Figure 4, illustrating the relative growth of the eye

		logarithmic form	arithmetical form
A	total range of sizes	$\log T = 0.025 + 0.938 \log V$	$1.059\ V^{0.94}$
B	Group 1, fetal eyes	$\log A = 0.045 + 1.042 \log V$	$1.110\ V^{1.04}$
	Group 2, birth to Group 3, over 20 mm.	$\log A = 0.116 + 0.521 \log V$	$1.306\ V^{0.52}$
	20 mm.	$\log A = \bar{1}.961 + 1.130 \log V$	$0.914\ V^{1.13}$

As already stated, sharp changes in the trends of biological values are uncommon and therefore to be critically regarded. It is unfortunate that the data here considered did not have a homogeneous origin as to author and method of measurement, and that the individual values are not available in each case. In consequence of the latter fact it is not possible to calculate any measure of statistical reliability for the first group. A general indication of the different relation existing between the axial and vertical diameters as compared with that between the transverse and vertical is furnished by the obvious differences between the graphs. The inhomogeneity of the data does not prevent the latter

graph from showing an apparently close relationship, and therefore can hardly be used to explain the apparent breaks in the graph of the axial on the vertical diameter. In a similar manner the third group is from two sources but shows no break.

A statistical analysis of the differences in slope is, as stated, only possible for the second and third groups. The chance that the second group could have come from a population in which the true slope was +1.00 is less than one in a thousand. In a similar way the chances that the slope of the third group represents a sample from a population with a slope of +1.00 is only one in five. The slopes of the two groups are significantly different. There is thus no doubt that there is a significant change in the type of growth at an equatorial diameter of about 20 mm. Although it cannot be proved, it is reasonable to assume that the apparent break at the time of birth (about 16 mm.) is also significant.

It is clear that the axial diameter grows in a different manner from the vertical and transverse diameters. In the smaller eyes the axial length grows more slowly than do the equatorial diameters, giving an eye relatively short for its equatorial diameter; above about 20 mm. it grows more rapidly giving a relatively long and of course a bigger eye. This is the average course of events. Unfortunately we lack longitudinal studies of particular eyes which would enable us to say that the axial diameter of any individual eye shows at first a relatively slow and later a relatively rapid growth. Perhaps each axial length grows at a con-

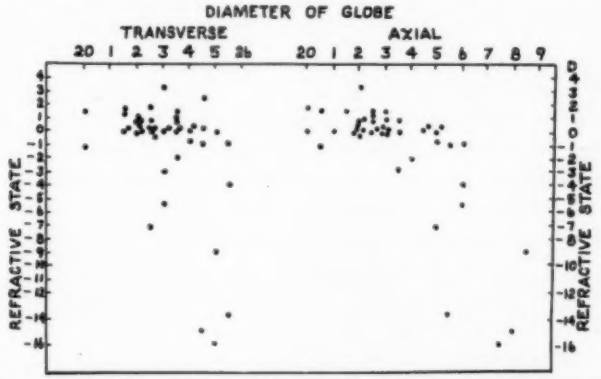

Fig. 5. Relation of transverse and of axial diameter to refractive state.

Coefficients of correlation:

transverse diameter and refractive state = —0.486 $0.001 < P < 0.01$

axial diameter and refractive state = —0.735 $P < 0.001$

stant rate but these rates differ widely from case to case, giving a composite picture of a changing rate.

A point that will naturally occur to the reader, but for which there is no simple and clear answer, is the relation of these changing rates to age. As already stated, an obvious relation between size of eye and age is only present during approximately the first year. Some eyes apparently must grow for a longer time or at a more rapid rate than others, resulting in an "adult" size more variable than that of the skull. An example will illustrate the difficulty of relating size to age. The eyes of two men aged 33 and 35 measured 20 mm. in transverse diameter, while three other eyes of the same diameter were found at the ages of 1, 2.5, and 6 years. The transverse diameter of the eye of a child of 8.5 years was 24 mm.; only 9 out of the 43 adults exceeded this value and the largest was only 25.5 mm.

The view of the growth of the eye presented above is in accord, for example, with the statement of Duke-Elder's, "The most rapid growth occurs in the first year of life; subsequent growth affects mainly the posterior segment" (Vol. 1, p. 368, 1934). From the progress of myopia in individuals it may safely be concluded that few eyes grow after the age of 18 or 20. The marked variation in the size of adult eyes must then result from differing rates of growth between birth and 18 years; in some, the final size is apparently reached long before this age. There are indications that the latter happens in many persons.

Several points of importance in understanding ametropia and, in particular, myopia, result from the type of growth indicated by the present study. Before pointing these out it must be emphasized that arguments as to the effect on refraction of the relation of axial to vertical diameter must be carefully qualified. It has been so often suggested and diagrammed in textbooks that myopia is due to a long eye, that it is sometimes forgotten that the power of the cornea and of the lens are also important. If we say that an increase in axial length makes the eye myopic it must be qualified that both cornea and lens remain unchanged. Since both the cornea and the lens vary with changes in the axial length, it is extremely unlikely that changes of the axial length are ever encountered in a pure form. Hence, conclusions can only represent a trend and only on the average will they be true. But even this qualified information may be extremely valuable.

The type of growth indicated by allometric analysis would lead us to expect in the first year or two of life, a shift of the refraction toward hyperopia and in later childhood a shift toward myopia. These tendencies have been observed in the refractive state of children. The

data of Santonastaso (1930) on 231 eyes of 82 individuals, perhaps the best available for the new born and children under one year, show that there is a statistically significant (P=.001) decrease in myopia and increase in hyperopia during the first year, in fact between those under 15 days as compared with those over 15 days but under 3 months. Brown (1942) noted a shift in the direction of hyperopia up to four or five years. For the period of later childhood the increase of myopia, the so-called "school myopia," is too well known to require documentation.

Long ago, Donders, to whom ophthalmic refraction is so greatly indebted for its sound foundation, suggested that the hyperopic was an incompletely developed and the myopic, an over-developed eye. The results of allometric study here presented are in agreement with this view but add certain points to it. The eye that stops at a smaller stage of growth has in general those proportions that will produce a hyperopic, at a larger stage, those that lead to a myopic eye. But it will be noted that not only long eyes but eyes big on the basis of either equatorial diameter will, on the average, be myopic. A disproportionally great axial length does not often occur in eyes of small equatorial diameter but is distinctly a characteristic of the big eye. It has been shown by several workers, but most clearly by Stenström (1946), that the refractive state is highly correlated with the axial diameter. In the 43 adults of the present study the transverse diameter shows a correlation of +0.49 with refraction. This is lower than the coefficient of +0.76 found by Stenström but it is significant to the 0.1 per cent level and clearly indicates that myopia is characteristic of the big eye.

The present study again serves to emphasize the importance of the growth of the eye upon the final or "adult" refractive state. It is earnestly to be hoped that more data such as that given by Deller, O'Connor and Sorsby will be made available for more complete studies of the relative growth of the eye.

SUMMARY

1. A statistical analysis has been made of the data on the diameters of the eye furnished by the anatomical study of Collins and of Weiss and the x-ray measurements of Deller, O'Connor and Sorsby.

2. The relation of size to age, as pointed out by Weiss, is that characteristic of the central nervous system. The eye is relatively large at birth, reaches the minimum adult size in some cases by one year, and the data analyzed indicate no appreciable changes after the age of 15.

3. The relative variability of the diameters as measured by the

relative standard deviation or coefficient of variation,

$C = 100$ standard deviation/mean,

is greater than that of most of the dimensions of the skull or of the height.

4. There is a positive correlation, high for biological material, between the possible pairs of diameters, particularly the vertical and the transverse.

5. In the x-ray data of Deller, O'Connor and Sorsby, the average transverse exceeds the average vertical diameter by a small amount which appears less significant than that of the corresponding anatomical measurements.

6. The full range of sizes available permits an allometric analysis of the growth of the eye, apparently for the first time. The vertical and transverse diameters grow at approximately the same rate, indicating that the equatorial cross section is constant in shape. In contrast, the axial diameter after birth increases at first less rapidly and later at about the same rate as the vertical. Apparently individuals differ greatly either in the rate at which, or in the time during which, the eye grows, or both. In consequence those persons in which the eye stops growth in a relatively early stage will, in general, tend to show a disproportionally short globe and will therefore usually be hyperopic, whereas those in which a large eye results from rapid or long continued growth will in contrast show a disproportionally great axial length and a myopic refraction.

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THE COSMETIC CONTACT LENS—A CASE REPORT*

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In addition to their use in correcting the various ametropias of the eye, contact lenses are often of value in certain other ocular conditions. Special contact lenses with lead dots implanted in the plastic material to form a geometric pattern are used in conjunction with the x-ray localization of penetrating foreign bodies. A contact lens made entirely of lead and plated with silver is used to protect the eye when the lid is being irradiated with x-rays. Contact lenses with minus power are used in conjunction with plus lenses in spectacles to form the ocular and objective of a sub-normal vision telescope. Contact lenses with painted iris and sclera and with a pinhole pupil may be used with advantage in certain other subnormal cases. Another type of contact lens contains a prism and is used with the gonioscope to explore the angle of the anterior chamber. Opaque contact lenses[1] with painted iris and sclera and without pupillary opening may be used for total occlusion in cases where binocular vision is impossible or impractical.

Another type of contact lens of considerable interest is known as the "cosmetic contact lens." This lens is used to cover blemishes of the cornea, iris or sclera. Such a lens may provide total occlusion when no sight is possible or it may have an open pupil for use in cases where sight is possible. When the blemish is confined to the sclera, a contact lens with the entire corneal area clear (no painted iris) but with an opaque painted sclera may be used.

While we have fitted a number of cases with the various types of cosmetic contact lenses in use, the following case history is typical and presents all of the problems usually encountered in fitting such cases:

Patient T. P., male, 39, visited the clinic for the purpose of determining whether anything could be done to correct a disfiguring scar of the left eye. The history revealed that the scar had resulted from an infection and a secondary glaucoma following an accidental injury in June, 1943, caused by a piece of hot steel which had perforated the

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cornea. The disfigurement was accentuated by the presence of a divergent squint.

Gross inspection revealed a dense, adherent leukoma which covered most of the cornea of the left eye. Vision was restricted to light perception. There was a slight divergent squint. The right eye was normal. Figure 1.

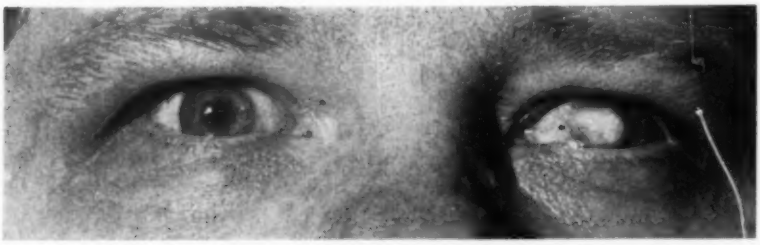

Fig. 1. Dense adherent corneal leukoma resulting from infection and secondary glaucoma following accidental injury by a piece of hot steel which had perforated the cornea.

By caliper measurements, it was determined that the pupil of the unaffected right eye measured 6 mm. under average illumination while the diameter of the iris measured 11 mm. These measurements are particularly important in the fitting of a cosmetic lens since the lens must match every possible detail of the unaffected eye if it is to serve its purpose.

In the past we have always used sets of artificial glass eyes to match the colors of the iris, the collarette and the sclera as well as the color and veining pattern of the sclera. The glass eye which was selected as the best match was then sent to the laboratory to serve as a model for the artist in painting the cosmetic lens. This method is inconvenient as it entails borrowing sets of artificial eyes from the manufacturers of glass eyes. Recently the Precision-Cosmet Company of Minneapolis placed on the market a set of cards which illustrate nearly all of the possible colors of the iris, collarette, sclera, veins, etc. These cards were used to match the right eye of this patient and color 6-C was selected as affording the best match.

The fitting of a cosmetic contact lens may be carried out by either the impression method or the trial case method. In this case, the patient was fitted with a Feincone lens size 4326+2 by the trial case method. The trial lens was adjusted so as to provide adequate corneal and limbal clearance and the corneal section was decentered nasally so as to eliminate

the appearance of the divergent squint. Adjustments on the trial lens were made both by grinding and by thermal adjustment with the use of the radius adjustment forceps. A casting of the adjusted contact lens was made in dental stone. This casting was sent, together with the measurements and color code, to the laboratory of Dr. William W. Policoff of Wilkes-Barre, Pennsylvania, who specializes in lenses of this type. Our experience with lenses fitted in the manner described above indicates that fewer adjustments are required on the finished lens than when the lens is made from an impression of the eye itself.

The greatest difficulty in adjusting the cosmetic contact lens lies in the fact that the lens is opaque. This fact makes it impossible to determine accurately the exact location of tight spots which may be causing rotation or decentration of the lens. In the case of a simple decentration, this is not too much of a problem since we know that a lens will usually decenter away from a tight spot.[2] Acting on this knowledge we can loosen the lens arbitrarily on the side opposite to the direction of the decentration until the lens is properly centered. In the case of rotation, the problem is not so simple since the rotation usually results from the presence of two or more tight spots.

When the lens for this patient was received from the laboratory and was put into position on the eye, the lens rotated itself almost immediately so that its long temporal edge became located superiorally and was made to press into the superior fornix. This caused the lens to be decentered inferiorally. It was noted that the palpebral aperture of the eye fitted with the cosmetic lens was wider with the lens in place than that of the other eye. No effort was made to correct this condition as experience has shown that the eyelid has a tendency to stretch and thus narrow the aperture after the lens has been worn for a few days.

Many hours were spent in making adjustments in an effort to stop the rotation of the lens. Admittedly it was a trial and error process

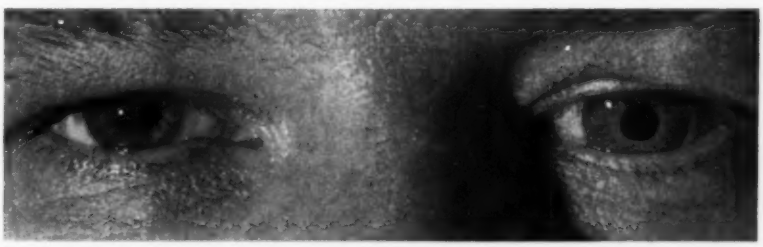

Fig. 2. Finished cosmetic contact lens. Pupil of right eye is dilated due to low level of illumination in room prior to flash photograph.

wherein first the nasal and temporal edges were loosened, a little at a time, then the superior nasal and inferior temporal edges were adjusted, followed by the inferior nasal and superior temporal edges, and so on around the lens. It is only natural that the constant insertion and removal of the lens should eventually cause irritation so that further work had to be postponed until another day. After several visits and repeated adjustments, the rotation was finally stopped and good cosmetic results were achieved. Figure 2. It will be noted that there is some difference in the appearance of the two eyes. Careful study will reveal that this difference is due almost entirely to the fact that the iris and pupil of the cosmetic lens are in the plane of the cornea rather than several millimeters posterior to this plane, as is the case in the living eye. Unfortunately we know of no way of overcoming this problem.

Since completing the above case, we have been experimenting with the cosmetic lens and believe we have found a method by which much of the uncertainty can be removed from the fitting of opaque lenses. In this method, a trial contact lens is adjusted to the patient's eye until a perfect fit is obtained. Two dental stone castings are then made of this adjusted trial lens. One of these castings is sent to the laboratory for use in fabricating the cosmetic lens, the other is retained for use in checking the fit of the finished lens. To check the fit, the dental stone casting is coated with a thin film of Prussian blue of the type used by machinists in fitting bearings. The cosmetic lens is carefully placed in position on the coated casting and slight pressure is applied. When lifted from the casting the inside of the lens will have blue markings indicating the points of contact. Theoretically the cosmetic lens should fit as well as the original trial lens, but in practice it is usually found that adjustments must be made. The making of these adjustments is greatly simplified by this method since tight areas, as indicated by the blue marks on the inside of the lens, may be loosened, a little at a time, until subsequent fittings on the eye and on the stone casting indicate a proper fit.

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SOME RELATIONS BETWEEN OPTICAL RESOLUTION AND RESPONSE*

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Experientially there are two extremes in the process of seeing. Or, perhaps, we might say that there are two *modes* of visual observation. One involves the immediate comprehension of geometrically complex material. In this mode of seeing, the fineness of elements is not a critical factor, so the observer's visual acuity is not involved as it otherwise would be. All the elements in the material subtend visual angles well above the minimum resolvable. Given sufficient time, the individual can see every detail perfectly well. In this mode of seeing, individuals vary greatly in their achievements. If the material is the printed page, one individual may comprehend a paragraph or two while another may be reading a couple of words. This difference in ability is of the utmost importance, but its basis is still not understood.

The second mode of seeing is that involved when highly localized portions of the visual field are inspected carefully. In this mode, a few details stand out vividly at any instant. This given mode may be spoken of as analytical in contrast to the first mode which we shall call comprehensive. In the analytical mode, the attention is centered upon detail, and in the comprehensive mode it is not. To speak of these modes in terms of attention does not explain their mechanisms, although it does suggest that central processes are crucial in distinguishing them.

It is obvious that in the analytical situation, visual acuity may be crucially involved in order that the finest detail of the material will look sharp. But in the comprehensive situation, some students of the subject believe that visual acuity is not brought crucially into play. It is likely, however, that some individuals confuse visual acuity and clearness of attention.

It is obvious that the distinction between the two modes of seeing poses certain fundamental problems in vision. All of the work that has

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involved the study of speed of reading and of recognition of material tachistoscopically presented would tend to throw light upon comprehensive observation. The work on visual acuity by laboratory methods as well as by clinical procedures has given us material on analytical vision. What is yet needed is a comparative examination of the resolution in the two modes of seeing. If visual acuity, as conventionally defined, measures the limit of achievement in analytical seeing, what measures optical resolution needed for comprehensive seeing? Is visual acuity as pertinent a measure in dealing with comprehensive seeing as with analytical?

From one standpoint, our problem concerns how visual acuity is involved in both modes of seeing. Is visual acuity differently involved in the two situations and is this difference such that blurred images are more usable in comprehensive observation than in analytical? This has a partial answer in the many classic experiments in which long groups of letters are seen as meaningful words, even when there are omissions and transpositions in the actual stimulus material. When certain constellations of items are involved, the configuration as a whole carries the meaning despite deficiences such as omission and transposition of certain details of the stimulus material. While this is true, will the uniform blurring of material impoverish the accomplishment of the observer as little as the localized faults just mentioned? The answer to this question might seem easily obtained. Material might be blurred to different degrees by the use of lenses. Actually, however, the question we are interested in has to do more specifically with what the poor or normal reader can do in such cases, in comparison with what the very rapid reader can do for it would seem that the two clear-cut extremes of analysis and over-all comprehension can only be obtained by using separate individuals, and not in any one person. Individuals varying considerably in their reading speed must be used. The difficulty lies in obtaining rapid readers as subjects. Apparently these must be trained. Furthermore, the training of them as by the recognition technique should add something to our own understanding of what is involved in the process of rapid reading: that is, the instantaneous comprehension of great amounts of material.

Motivated by assertions, that visual acuity is not involved in the process of reading print, I set out to make a test of the matter. The proposal was to train subjects in rapid reading by the recognition method and then to determine what blurring would do to their accomplishments in comparison to those of normal or poor readers. The supposition was that poor readers were definitely analytical in their mode of

performance. It was supposed that they tended to see words instead of phrases or larger groupings of words. In fact, they might even attend to single letters at times. Rapid readers would supposedly employ the comprehensive mode of observation and would less probably attend to isolated items. When the rapid readers were trained, it was proposed to introduce blur in varying amounts by the application of plus and minus lenses. If the idea was true that visual acuity was materially less crucial in the case of comprehensive observation than in analytical, then it was supposed that blurring should not reduce the achievement of the comprehensive readers until a considerable amount of it should be introduced. In contrast to this, blurring would conceivably begin quite soon to impoverish the achievement of the normal or poor readers.

The purpose of the present paper is not to report on findings of the recognition experiments, but rather to deal with factors involved in tachistoscopic observations which were brought to attention in the early stages of the recognition experiment. More specifically stated, the present paper is a report on the findings obtained from varying observation distance, and target exposure times, and from measuring reaction times in relation to observation distance. To introduce these findings, reference is first made to the recognition experiment itself.

The material used in the recognition training was ½" black letters on a white background, exposed for 1/100 second and viewed from a distance of 6 feet. One observer with uncorrected vision of 20/30 when using both eyes reported the following:

When the exposure time was 1/100 second, he could not detect that any material at all was exposed. The field constituting the transient stimulus was entirely homogeneous. When the exposure was increased to 1/50 second, he could see a sort of a dark blur which he could presume to be some letters. When the time was increased to 1/25 second, one or two letters could be seen though not necessarily correctly. With a 1/10 second exposure, he could see that four letters were presented and could possibly identify two of them. With a 1/5 second exposure, three letters could be identified on some trials. With a ½-second exposure, all four letters could be well identified.

Following this check, the subject was moved in to a 4-foot observation distance. Here with a 1/100 second presentation all four letters could be seen and two or three identified correctly without practice. At 1/50 second exposure the performance was slightly better. At 1/25 second exposure, three letters could be well identified. When he was moved in to a distance of 3 feet· all four letters could be identified with an exposure of 1/100 second.

Under the conditions used in the experiment, letters exposed indefinitely were seen at their maximum sharpness out to a distance of about 4 feet, whereas the letters could be identified as far away as 12 feet.

These observations indicate, of course, that shortening *time* as well as increasing *distance* reduces achievement even when the size of the target elements was such as to make them visible to ordinary observation at a distance away beyond the ones used in the above tests. Since the observer was working with material much above his lower limit of resolution, visual acuity according to common measures, was not at issue. The findings do, however, remind us that for some purposes the single fixed measure or value for visual acuity does not tell enough of the story of seeing.*

If the subject whose performance was described could identify the letters at a distance of 12 feet, when the exposure time was *not* limited, it is obvious that time becomes a limiting factor that reduces visual accomplishment long before ordinary visual acuity limits are reached. Shortening exposure time in tachistoscopic experiments is simply one way of showing the various levels of accomplishment are limited by time. Such conditions are a variation of the standard reading situation in which some individuals require much more time than others do to accomplish the same or an equated task. In the one case, the time factor is limited *for* the observer; in the other, the observer determines his own time.

If the distance of 12 feet, in the example, was the point at which the retinal image becomes too blurred to function as a definitive stimulus, then, as distance is lessened, the image may be expected to improve. Achievements that are determined at each of these shorter distances represent times needed for impressions by certain sub-optimal retinal images. These may be related to the times required to set up boundary processes in the retina. Boundary processes have been studied in other ways by various investigators such as Werner, and Fry and Bartley. It is scarcely needful to describe their findings at this time, but it is significant to keep

*We do need to know how visual accomplishment varies with varying lengths of exposure. And when the time function is ascertained it may not be the same for each observer. With short exposures, some individuals may not react as well as might be expected from their long-exposure visual achievement. It might be needful to know, in addition to the individual's long-exposure visual acuity, certain short-exposure or tachistoscopic visual acuities. Also certain low-intensity visual acuities might be significant. Naturally, there are almost unlimited numbers of values that might be termed visual acuities, or given analogous labels, but for most purposes a few chosen representative measures would be sufficient in characterizing performance.

in mind such studies with those that are more specifically related to practical pursuits.

EXPERIMENT I

Conditions. From the preliminary findings just reviewed, it became of interest to study the effect of exposure time upon what an individual is able to see. Whereas the usual material for recognition experiments is letters or digits, it was thought best to use some sort of simpler material for this purpose. By its use, the learning factor would be reduced to a minimum. Accordingly, a single fine line was used. In order to make the observation procedure more appropriate, this line was shown in each of 8 different positions, an equal number of times in random order. The line in each case was confined within a circular area, as would be the hour hand of a clock at various hours of the day. Presentations were made in groups of 32 trials, each line position being repeated four times. Several such groups of trials were made for each of a number of combinations of conditions. The lines were made in black India ink, on white card, and enclosed within a 3-1/16-inch circle. For timing exposure, an Ilex shutter was placed on a Clason visual acuity meter used as a projector. Each exposure consisted in an 11-inch square of light being flashed upon a white screen, the center of which was concentric with the center of the card. Since no intentional illumination in the room was used, a band of luminescent paint bordered the card position to provide somewhat of a direction indicator, if not a fixation point.

Three different exposures were employed; namely, 1/100, 1/5, and ½ seconds. Three different subjects, two of whom continued throughout the experiment, were used. For each of these exposure times, responses were gained from the subjects at from 3 to 8 different observation distances, generally at 5 or 6. The range of distances depended upon the ability of the subjects to respond. It is well-known that if a response is made easy enough it will be made correctly in virtually 100 per cent of the trials; if it is made difficult enough, it can never be made correctly, except by chance.

Discussion and Results. The results were first plotted to show the relation between the percentage of correct responses and distance, for each of the three different exposure times. Thus, for each of the two subjects, there were three curves, one for each exposure time. Naturally, for each set of conditions, for each subject, some variability was manifested. Despite the variability, the points in each of the plots seemed best described by a straight line. Accordingly, by inspection, a straight

line was drawn through each of the clusters. The slopes of these lines were fairly similar for all of the plots. (See Figure 1 and Table 1).

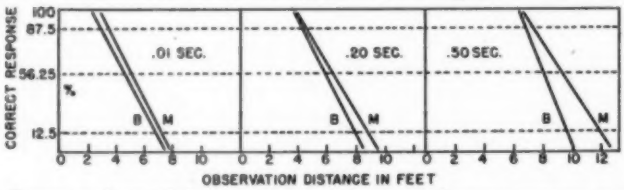


Fig. 1. Curves to show relationship between percentage of correct response to a briefly exposed fine line, and length of exposure, and observation distance. Curves B and M are for two different observers.

Ordinarily, as a stimulus magnitude is plotted against percentage correctness of response the function is sigmoid. That is, instead of the curve being a straight line, it is S-shaped. In the present case, however, it is impossible to see how one could extract an S-curve from the manner in which the points clustered in the plots.

TABLE I

Range over which improvement occurs.

	1/100 Sec.		1/5 Sec.		1/2 Sec.	
B 100	2.9)		4.2)		7.0)	
87.5	3.5)		4.9)		7.5)	
56.25	5.2)	4.7	6.5)	4.6	8.7)	3.5
12.5	7.6)		8.8)		10.5)	
M 100	3.4)		4.4)		7.5)	
87.5	4.0)		5.0)		8.2)	
56.25	5.7)	4.6	7.1)	5.4	10.3)	4.7
12.5	8.0)		9.8)		12.2)	

The above table indicates the distances at which certain percentages of correct responses might be expected to be made for each of the two observers, B and M, for each of the three exposure times. Percentages of 100, 87.5, 56.25, and 12.5 were chosen for the following reasons: The 12.5 per cent point represents the number of cases out of 100 in which correct responses could be expected purely by chance, since there were 8 possibilities. At this point then, the poorest performance that could be credited to seeing would begin. The 87.5 per cent point is simply a point symmetrical on the curve to the 12.5 point. Although it is not customary to talk about a 100 per cent point on a performance curve, in this case, it would seem not to be prohibited. If so, then the viewing distance corresponding to this point would be the distance at which the best performance would begin. According to customary procedures in psychophysics, a threshold point is chosen, and is generally defined as the value on the scale halfway between chance performance and perfec-

tion. In this case, since chance is represented at 12.5, the threshold would be the 56.25 per cent point. It would seem that a whole performance range rather than a single point is significant in this investigation, hence neither the threshold nor a value taken to represent conventional visual acuity are the only measures to consider.

Not only is the whole range important here, but it is of very practical significance in predicting what will happen in life situations. Behavior is often not best thought of as an all-or-none affair, nor a right or wrong kind of response, but rather in terms of probability of being right or wrong. Improvement is then stated in terms of increasing probability of being right. If we are talking about a motorist seeing a pedestrian on a street on a rainy night, we may well talk in terms of probabilities. In fact, that is about the only way that we can logically describe matters, or make predictions. We may say that with a certain distance involved, with a certain level of illumination, etc., etc., the chances are so many in a hundred that he will see the pedestrian. We cannot say that he will or will not, even under all the known conditions that we can assemble.

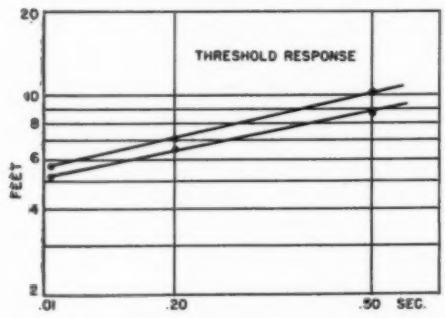
Visual acuity is not defined psychophysically but is considered to be some all-or-none performance. A patient reads all of a line of a given size of print, or none of it. If, perchance he reads a sizeable fraction of it, credit by interpolation may be given in some cases. The fractional performance is utilized not as in psychophysics, but to give distance credit. Thus, whereas in the clinic, visual acuity is defined in terms of just being able to accomplish a visual task, in psychophysics visual performance is measured in terms of threshold, which is defined as the stimulus conditions underlying a certain percentage of successes out of a large number of trials. The threshold is a statistical concept. Since visual acuity is measured in terms of just being able to accomplish a visual task, the probability of doing that task a certain number of times out of a hundred is not taken into account.

However, in the present case, visual acuity might be defined by some point on the performance curve such as the 12.5 per cent point. This point represents visual performance beyond the expectations based on pure chance. If this be the case, then it should be obvious that performance gets better as target material becomes grosser in its elements, or as viewing distance becomes shorter, and that this improvement continues over a considerable range. The results just presented are an example of this improvement. Hence for certain predictive purposes, levels of performance above those defined by conventional visual acuity are appropriate.

For example, we say that subject B, at 1/100 second, at 7.6 feet from a target, as represented in the conditions of the experiment, will make a correct performance only as if by guessing. He will improve until he reaches 2.9 feet where he will make a virtually perfect performance in terms of percentage of correct responses out of a large number of trials.

If the 7.6 feet, as indicated previously, in some way represents a limiting condition comparable to what is sometimes implied in a visual acuity measure, then improvement occurs throughout 62 per cent of the way from the point taken to measure visual acuity to the target itself for subject B, and throughout 57.5 per cent of the distance for subject M. Even if we took the psychophysical threshold value as representing visual acuity, then the percentage of the distance from the visual acuity point on in toward the target throughout which improvement would occur was 31.7 for B, and 28.7 for M.

So far, we have been dealing with the variability in the likelihood that a target will be seen as *distance* is reduced from the point at which it just can be seen. If we compare the viewing distances and the *exposure times* for any given percentage probability, we can show the effect of lengthening or shortening exposure time. To do this, let us compare the distances for the various exposure times for a threshold or 56.25 per cent probability. For subject B to perform equally well, he must be at 5.2 feet for an exposure of 1/100 second; 6.5 feet for 1/5 second, and 8.7 feet for ½ second. For subject M, for the same three exposures, the distances are: 5.7 feet, 7.1 feet, and 10.3 feet. When the logarithm of the viewing distance is plotted against the exposure time, the relation



RELATION OF OBSERVATION DISTANCE TO EXPOSURE TIME

Fig. 2. Curves showing the relation between threshold response (correct in 56.25 per cent of cases) and observation distance and target exposure time. The two curves are for two different observers.

is linear, over the range used in the experiment, and the curves for the two subjects lie close together and are nearly parallel. (See Figure 2.) Time and viewing distance can be traded, when considering equal performance although not on equal terms.

There is another way of relating time and the other factors involved in performance. In the first case, we equated performance; in the present case, we shall equate distance and manipulate time and percentage probability of correct performance. The following table indicates the outcome:

TABLE II

Subject B:	6 feet.	7 feet.	8 feet.	9 feet.
Time: 1/100 sec.	42.5%	22.5%	6.5%	.....
1/5 second	66.5%	47.5%	28.5%	10.5%
1/2 second	.....	100.0%	74.5%	50.5%
Subject M:				
Time: 1/100 sec.	50.5%	30.5%	10.5%	.....
1/5 second	74.5%	58.5%	42.5%	26.5%
1/2 second	.....	.....	90.5%	76.5%

It will be obvious from the table that the percentage probability of correct responses varies considerably with exposure time. For both subjects, the best examples of how excellence of performance is manipulated by exposure time is shown for the viewing distance of 8 feet. The relation between percentage probability of correct response and exposure time is almost, if not actually, linear. The percentages that result cover a large part of the whole possible range.

EXPERIMENT II

Conditions. There is still another aspect of the situation which would seem crucial from a practical standpoint, and that is the time required for responding. This is more familiarly known as reaction time. We have already shown that as distance is increased, the probability of correct performance goes down. As exposure time is reduced the probability also goes down. The question now is whether the time required to act increases as either the exposure time is shortened or as the viewing distance is increased. We have some information on the latter, but not on the relation of exposure time to reaction time.

To study the relations between reaction time, viewing distance and per cent probability of correct performance, an entirely new setup was constructed. This involved two rooms, one for the subject, and the other for the experimenter. The target was placed in position at an aperture in the wall between the two rooms. Only four line positions instead of eight were used. The targets consisted in disks of translucent

plastic upon which the lines were drawn in India ink. These disks were carried on a large wheel, the axis of which was eccentric to the viewing aperture. The desired target was put into place merely by turning the wheel the proper amount. The Clason was used to provide a constant illumination around the 3-1/16 aperture. The intensity of this illumination was 1/10 that of the target which was 1.05 c./ft.^{2} Between trials, the target disk was dark. The light source for the target exposure was in the experimental room, and consisted simply of an enclosed box bearing an Ilex shutter. When the shutter was tripped, a chronoscope was set into motion. It was stopped by the subject's pressure on any one of four reaction keys. These keys were operated by the first two fingers of each hand, each key being assigned to indicate the exposure of the stimulus line in a certain position. The subject's pressure on a given key not only stopped the chronoscope, but also lighted one of four lamps in the experimental room, telling in which position the subject saw the line.

The width of the line was 1/48 inch, whereas the line width in the first experiment was 1/32 inch. The viewing distances for the two subjects were quite different owing to their differences in visual acuity. One had an uncorrected visual acuity of about 20/22 for binocular observation, and the other a visual acuity of 20/30 or slightly better.

The two subjects were also quite unlike in reaction times. Each subject was, in effect, his own control. That is, comparisons were made only within the performance of the subject himself, and not between subjects. In the present tests, sets of 32 trials were made with 8 exposures in each position. Average reaction times were obtained from as many as seven groups of trials for a given set of conditions.

TABLE III

Discussion of results. The following are the findings:

Distance (ft.)	% correct	Reaction time	SD.
	Subject S		
11.75	71.8	91	25.6
10.75	81.3	81	27.3
9.75	87.5	81	23.8
8.75	94.0	79	25.0
	Subject B		
6.75	50.0	145	43.3
5.75	64.7	128	39.3
4.75	78.0	104	30.6
3.75	98.5	102	36.5

When the percentage of correct response was plotted against the logarithm of the distance, the result was linear for both subjects. The slopes of the curves in the two cases were similar.

The absolute magnitudes of the reaction times from trial to trial varied considerably and did not seem to cluster normally. Out of the 32 trials in a group, the responses in most of them might cluster closely around some mean, but the remaining few might be enormously slower. To demonstrate the complete lack of normality, standard deviations were calculated for the reaction times and are shown in the fourth column of the table. It will be noted that they are ridiculously large. If these values are multiplied by 3 and subtracted from the mean reaction times to indicate the theoretically expected shortest reaction times, absurd values result.

However, it can be said that, in general, the mean reaction times become greater the greater the viewing distances. While the points do not precisely lie on a straight line, with our present information, a linear function is as good or better than any to suppose between viewing distance and reaction time. We can summarize the findings in another way by saying that for subject S, as viewing distance increased from 8.75 feet to 11.75 feet, reaction time, on the average, increased from .79 to .91 second. For subject B, as viewing distance increased from 3.75 feet to 6.75 feet, reaction time increased from 1.02 seconds to 1.45 seconds. (See Figure 3.) In other words, as viewing distance increased

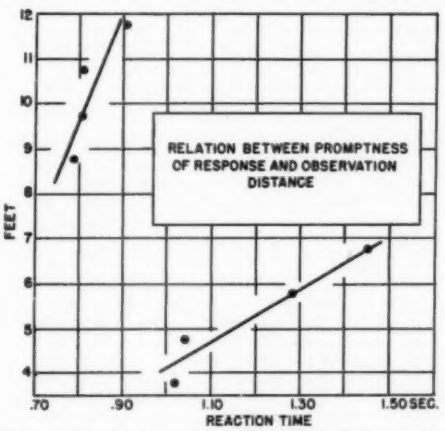


Fig. 3. Curves to show relation between reaction time and observation distance for two different observers. Each curve represents a single observer.

34.2 per cent, the reaction time increased 15.5 per cent for subject S. For subject B, as the viewing distance increased 80 per cent, the reaction time increased 42 per cent.

It would seem then, that when the retinal image is less sharp, the

time taken for its utilization is longer. The conditions of the present experiment may not indicate how great this slowing up of reaction may be under all conditions. The subject was set to react in all cases by a warning signal, and hence tended to react quickly whether right or wrong. Quickness of response was a goal for the subject. This was abetted by the fact that the circular target bearing the stimulus line was a bright area which loomed up suddenly to replace a dark area. This brightness was a constant and therefore it may have introduced a constant stimulus factor masking somewhat the variation of line thickness at several distances used. To test this, the emergence of the line should occur on the same background that exists in the fore period.

Be this as it may, the present information indicates that when individuals are performing with images below maximum resolution they tend to react more slowly than otherwise.

ABSTRACTS

VISUAL JOB ANALYSIS AND PRESCRIBING FOR SPECIAL WORK DISTANCES. Hedwig S. Kuhn. National Society for the Prevention of Blindness, Inc., 1790 Broadway, New York, N. Y. Publication 418. 15c.

For those interested in industrial vision work, it is essential to become acquainted with the specific mechanics involved by a careful visual job analysis of the entire plant to be surveyed. Any one of several visual functions may be important on a given job: (1) Distance acuity; (2) Near acuity; (3) Distance muscle balance; (4) Near muscle balance; (5) Color vision; (6) Stereopsis; (7) Multiple work distances; (8) Illumination; (9) Work in motion or stationary; (10) Hazards such as glare, foreign bodies, fumes, flash, etc.; (11) Are bifocals permissable, and (12) What degree of perfection is required?

A sample chart for visual job analysis and examples of various types of industrial operations are presented. Also, some examples are given of jobs in which bifocals and trifocals would be helpful and in others where they would be a handicap.

An interesting observation is that the incidence of visual defects among new applicants in industry is nearly the same as that shown for those already employed in industry. This refutes the theory that industry produces visual defects through strain or other causes.

The need is stressed for accurate adjustment of workers' glasses and goggles and for special types of corrections including inverted bifocals. The author states: "Here is one place where I find the optometrists are far ahead of us; they usually do know how to do these things and do them expertly."

Ophthalmologists cannot do all the refracting that is necessary in industrial plants. The author recommends that a competent optometrist work with the ophthalmologist.

The various screening devices: The telebinocular and the orthorator are discussed briefly. The author emphasizes that ordinary office techniques can rarely be used for industrial work. It is essential to study the visual requirements in the plant for the various jobs, and it is necessary to meet and to cooperate with lay management, employment directors, safety men, union representatives, etc. It is also pointed out that those professional people working in plants should provide practical answers and not aim to use industry to feed their private practices.

R. E. B.

THE CONTROL OF OCCIPITAL BRAIN WAVE FREQUENCY, VOLTAGE, AND WAVE FORM BY MEANS OF FLASHING LIGHT STIMULI*

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There are many causative factors contributing to the process of seeing: radiant energy transmission, retinal image formation, photoreceptor activity, optic nerve impulses, and occipital cortex activity. Of these, the brain activity is the most immediate causative factor of visual perception, as well as of other forms of human consciousness.

Of the causative factors of seeing, light waves are, so to speak, "out in the open" and easily studied. Retinal image formation, occurring within the eyeball, is somewhat more difficult to investigate. Optic nerve impulse transmission is still less accessible and necessitates special methods of investigation. Brain activity, the immediate causative factor of visual consciousness, existing within the confines of the skull, is the least accessible for investigation.

The activities of the brain are at least partly electrical in nature, and fortunately, the electrical aspect of brain activity is not confined to the brain, but permeates the skull where it can be measured by electrodes placed upon the surface of the skull. These electrodes transmit electrical potential changes through an amplifying system to be recorded as "brain waves" upon a moving kymograph. Such studies are referred to as electroencephalography.

Electroencephalographic investigations have shown normal conscious states to generally correlate with a certain range of brain wave frequency, voltage, and wave form. As the retina is sensitive to a certain spectrum range of electromagnetic wavelength or frequency, so normal consciousness depends upon a certain brain wave frequency, approximately 8 to 12 waves per second. Abnormally slow frequency of 5 or 6 per second exists during deficient conscious states, as sleep or anesthesia. Abnormally fast frequencies of 50 or more may accompany epileptic conditions. With extreme high or low frequencies consciousness ceases.

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Normal voltage is 5 to 50 microvolts (Mv). During epileptic seizures the voltage may reach 200 Mv. Normal wave shape is similar to a sine-wave, though less perfect. During psychomotor disorders, waves become flat-top, while during seizures spiked waves or a hump-spike formation may occur.

The great majority of electroencephalographic work has been diagnostic. The characteristic brain wave frequency, voltage, and wave form of many brain conditions having been investigated, an electroencephalograph is then taken of a patient to discover his brain condition.

A few investigations have dealt with attempts to control the brain wave frequency, voltage, and wave form by visual and other forms of stimulation. The remainder of the report will be a brief condensation of a few such studies carried on by several investigators* at the Division of Psychiatry, Billings Hospital, University of Chicago. Detailed reports are given in references 7, 8, 9, and 10.

Because it was desired to study subsequent to these experiments, the effects of artificially produced retinal, optic tract, and cortical lesions upon the ability to control brain waves by intermittent light flashes,[10] 20 adult monkeys (mocaca mulatta), rather than humans, were used.

Electroencephalograms were simultaneously recorded on paper tape from both occipital regions by means of a three-channel amplifying equipment. Flash intervals were also recorded continuously on the tape by means of a photocell pickup working into the third amplifying channel.

Stimulation was carried out with each monkey in a darkened, electrically shielded cage. The animal was attached to an animal board and placed before an aperture in one side of the shielded cage in such a manner that flashes of light introduced through the aperture gave an equal illumination to both eyes of 120 footcandles. Light from a tungsten source was interrupted at various frequencies by means of an interposed episcotistor driven by a DC motor controlled by a rheostat. A light-dark ratio of 1/1 was employed throughout.

Two convex lenses and a plane mirror were employed to condense and direct the light from its source to the surface of either neutral or monochromatic filters which were placed individually into a filter holder located at a distance of 25 cm. from the eyes of the monkey. An optical image was thus formed in the plane of the filter with the light diverging from that point to the eyes of the animal. In each experiment both

*The investigators included Dr. Ward C. Halstead, psychologist, Dr. Jack T. Woolf, psychiatrist, Dr. A. Earl Walker, brain surgeon, and the present author.

pupillary and accommodative reflexes were eliminated by instillation of 0.5 per cent solution of scopolamine hydrochloride into the conjunctival sacs of both eyes. Stimulation was never begun until mydriasis was complete. Blinking movements were eliminated by continuous use of lid retractors during stimulation: a bit was employed to prevent head movements.

In preliminary studies of 12 monkeys the illumination at the pupils was kept constant at 120 footcandles by a neutral filter, and the effects on occipital brain waves were analyzed. It was found that frequency, voltage, and wave form were altered and could to some extent be controlled by variation of the flash frequency rate. The effect seemed to work by an all-or-none principle. At one particular instant, the brain waves would be entirely independent of the flashing light. At another particular instant the brain wave frequency would jump to the exact frequency of the flashing light, would become more similar to a regular sine-wave formation, and would increase in voltage. These periodic control periods are spoken of as conditions of "driving;" the flashing light is said to be driving the brain waves relative to the flash characteristics of the visual stimulus.

The cause of either the sudden functional contact between the occipital brain waves and light flash frequency, or the sudden break away of the brain waves from control by the light stimulus is not known. In some monkeys a situation existed somewhat analogous to the break and recovery of duction movements. One monkey, for example, would be driven within or near the normal frequency range, but would break contact whenever the flashing light became less than 6 flashes per second or more than 11 flashes per second. Another would not be driven below 9 nor above 13, another not below 5 nor above 12 flashes per second. Each monkey seemed to have his own characteristic range of contact. Related to this, abnormal frequency waves were driven into normal frequency by a flashing light of 10 per second more readily than normal waves could be driven into an abnormal frequency by a slow or a fast flashing light.

Driving raised the voltage on the average about a 60 per cent increase over non-driving voltage. The greatest voltage increases were found during frequencies between 10.5 and 11.5 flashes per second. The increased regularity or stability of the wave form is demonstrated by brain wave photographs of driving and non-driving records in reference 7.

Through the ranges of flash frequency (2 to 13 flashes per second)

over which driving could be produced, the average monkey showed driving 55 per cent of the time. Considerable individual differences were present, the most drivable monkey was driven 78 per cent, and the least drivable 28 per cent of the time. In a few cases, a flash frequency produced a brain wave frequency exactly double or exactly triple the rate of the light flash.

In further investigations the effects of both wavelength and light intensity were studied. Eight monkeys were used under similar conditions to the first experiment except that different transmission neutral filters were used giving pupil illumination variations from 4 to 120 footcandles. A plot of percentage driving and illumination showed an increase in per cent driving up to 80 footcandles with no significant change above 80 footcandles. The per cent driving at 80 footcandles was twice the amount at 4 footcandles.

Wavelength effects were studied by the use of Wratten monochromatic filters #70 to #75, and a constant illumination of 4 footcandles. The maximum transmission of each filter from #70 to #75 varied as follows: 700, 650, 610, 585, 530, and 490 mμ. Their wave length range averaged 84 mμ.

The blue end of the spectrum (λ Max 490 mμ) was found more effective than the red end (λ Max 700-610 mμ); giving 55 per cent driving for blue as compared to 30 per cent for red. The middle of the spectrum was intermediate. Even the red light was more effective than equally luminous white (neutral) light, 30 per cent for the red compared to 23 per cent for white light. The average colored light was 50 per cent more effective than the neutral light, while the blue was nearly two and a half times as effective as the neutral light. The reasons for these differences have not been determined.

Some neuropsychiatric disorders are believed to be, in part at least, abnormalities of the electrical rhythm of the brain. If abnormal electrical rhythm can be made normal, though temporarily, by visual or other forms of sensory stimulation, there remains a possibility that electroencephalography may some day be a part of therapeutic programs, as well as a diagnostic technique.

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ABSTRACTS

STUDY OF VISION TESTING PROCEDURES. Thomas E. Shaffer, American Journal of Public Health. 38.1141-1146. August, 1948.

This report concerns observations made during a study of the vision of 203 school children carried on at the University School, Ohio State University in the spring of 1947. The study was a cooperative undertaking by members of the staffs of the College of Medicine, the College of Education, and the School of Optometry. Acknowledgment is made for the services of Dr. Claude S. Perry of the Department of Ophthalmology and Dr. Glenn A. Fry and Dr. Howard F. Haines of the School of Optometry.

The purpose of the study was to evaluate several widely known screening methods for testing visual function, and to present some facts upon which plans for a vision testing program could be based.

The tests used were The Massachusetts vision test, The Keystone telebinocular test, and the Snellen test. The latter test consisted of the illiterate "E" chart, properly illuminated. Each child was also given a complete eye examination, including refraction with and without cycloplegia.

As a result of comparing the number of cases selected by the various screening procedures as needing attention with the findings of the complete eye examinations, **the following comments are made:**

"The Snellen Test for visual acuity at 20 ft. is the most reliable single screening procedure, when carried out carefully and with proper illumination. It should by all means be included in testing programs in schools."

"The Keystone telebinocular, when the entire battery of tests is used for a screening procedure, has a much higher over-referral rate than the Snellen Test and is not significantly more accurate in finding cases in need of referral. Unnecessary referrals, without increased case finding efficiency, are not economical. This criticism does not refer to the possible usefulness of the telebinocular in investigating readiness for reading and reading failures, a matter we have not studied."

"The record of the Massachusetts vision test, both in selecting cases in need of referral and in the margin of over-referral, seems too low for the purposes of a screening test in schools. Since the Snellen test is included in the Massachusetts test, more exacting criteria for referral would achieve at least the efficiency of the Snellen test as employed in this investigation plus the cases discovered by the plus-sphere and Maddox rods. More rigid standards are particularly needed in the older school-age groups, where even small refraction errors merit careful evaluation."

R. E. B.

USE OF CONTACT LENS IN CASE OF MONOCULAR KERATOGLOBUS—A CASE REPORT*

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CASE HISTORY

Eight years prior to our first contact with R. H., age 37, the patient noted that the vision in his left eye was growing poor and at the same time that the eye was turning out. The loss of vision of his left eye was proving to be a handicap in his occupational tasks. At the time of this initial examination the exotropia was 25°. The patient was not wearing a correction.

PRELIMINARY FINDINGS

Vision was: O. D. 20/25. O. S. 2/200. O. U. 20/25—.

An apparent left divergent strabismus was in evidence. The lids, sclera, and conjunctiva were healthy and of normal color. There was no active pathology. The size of the pupil in each eye was normal.

OPHTHALMOSCOPIC FINDINGS

O. D. Cornea clear. O. S. Cornea was clear and there was no break in Descemet's membrane. The curvature of the cornea was irregular with the greatest bulge located in the superior temporal quadrant of the cornea. The iris was regular in shape. It was difficult to secure a good view of the left retina. The patient was referred for ophthalmological study and returned with report negative and no treatment indicated.

ANALYTICAL FINDINGS

Subjective:

O. D. +0.50 D. sph. V. A. 20/20.

O. S. Lenses provided no increase in V. A.

As no correction was found which would improve the visual acuity of the left eye, a contact lens seemed indicated, and was prescribed. With the trial lens in place the following findings were secured:

Static retinoscope:

O. D. +0.75 D. sph.

O. S. —2.00 D. sph.

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Dynamic retinoscope:

O. D. +1.50 D. sph.

O. S. —1.50 D. sph.

Subjective:

O. D. +0.50 D. sph. V. A. 20/20.

O. S. —2.00 D. sph. V. A. 20/25. (Contact lens).

Cross cylinder (near):

O. D. +1.25 D. sph.

O. S. —0.75 D. sph.

Amplitude of Accommodation:

O. D. 5.00 D.

O. S. 3.75 D.

O. U. 5.00 D.

Tolerance to accommodation stimulation at 16 inches, —2.00 D.

Tolerance to accommodation inhibition at 16 inches, +1.75 D.

The patient is able to wear the contact lens with complete comfort throughout the day with periodic (every 5 hours) changes of the solution. Motivation throughout was strong and the cooperation offered was excellent. The patient expresses a notable increase in the field of vision particularly in the left field.

A progress report made six months following the fitting of the contact lens shows no further progression in the deterioration of naked vision. Corrected vision is still 20/25+, in the left eye.

A corrective program is now being initiated aimed at remedying the manifest strabismus.

ABSTRACTS

FACTS CONCERNING COLOR VISION IN DRIVING. Edwin D. Fletcher. The Associated Journal of Optometry. 15.6.4-5. 1950.

The author, who is an official of the California State Division of Drivers' Licenses contends that the presence of color blindness should not bar an applicant for a drivers license. He points out that the tests for color blindness and the signal lanterns in use in traffic are quite different and justifies his position on the ground that color blind drivers memorize the position of the green-yellow-red lights and can thus tell when a particular signal is on. In California color blind individuals are given drivers' licenses. The paper was prepared for Optometric Extension Program consumption.

C. C. K.

GERMICIDAL LAMPS*

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During the past few years special lamps have been developed which produce ultra-violet radiations that under certain conditions destroy air-borne bacteria, spores and molds. The wave lengths of ultra-violet radiation used by these lamps are similar to the radiation from the sun except that the lamps produce the radiation in greater concentration.

The radiations as shown on the spectrum, in common use, are the infra-red radiation which produces heat and is invisible to the eye, the visible portion of the spectrum from approximately 7600 Aμ to 3800 Aμ, which is the portion of the spectrum used to stimulate the rods and cones in the retina and the ultra-violet radiation, which have a number of uses but which are also invisible to the eye. Figure 1.

These forms of radiant energy differ only in the lengths of their waves. The infra-red are the longest: the ultra-violet are the shortest and the visible light waves are in between as noted above. Such wave lengths are measured in terms of angstrom units. An angstrom unit, Aμ, is the length of one ten-millionth of a millimeter or four-billionths of an inch.

Visible energy or light is broken up into the colors of the spectrum produced by the energy of different wave lengths as can be easily demonstrated by passing a beam of light through a suitable prism.

Ultra-violet energy has an approximate range from 4000 to 1000 Aμ. The following table demonstrates how the ultra-violet spectrum may be divided approximately into four parts according to one or more principles, effects or uses:

1. Up to 2000 Aμ., production of ozone.
2. 2000 to 2800 Aμ., sterilization by killing bacteria.
3. 2800 to 3200 Aμ., supplied by sun lamps for health purposes.
4. 3200 to 4000 Aμ., for photographic and fluorescent display range.

Actually and practically these divisions overlap considerably.

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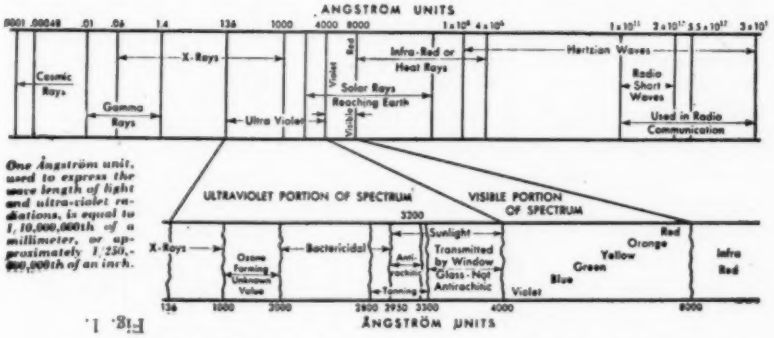

FIG. 1.

The wave lengths of the ultra-violet energy in the commercial lamp are approximately between 2000 Aμ and 2800 Aμ. Most of these wave lengths are at 2537 Aμ., which is the point at which the energy is most effective in destroying bacteria.

1. OPERATION

This germicidal lamp is almost identical in its operation to the fluorescent lamp. The only difference being the lack of fluorescent powder in the lamp. Instead of activating fluorescent powder on the inside of the lamp, the ultra-violet energy passes through the special glass used in the globe of the lamp.

2. FACTORS AFFECTING THE OPERATION OF SUCH LAMPS

a. Humidity:

The amount of humidity has a definite effect on the ability of ultra-violet at 2537 Aμ., to kill air-borne bacteria. At ordinary room temperature (70°) it requires several times as much radiation to destroy bacteria at high humidity as it does at low humidity.

b. Temperature:

The ultra-violet output of the lamp is materially reduced by low temperatures. For example: in still air, it will be approximately 60 per cent of normal at 32° F. and 30 per cent at 0° F.

c. Production of Ozone:

These lamps generate a small amount of ozone which corrects odors and aids in killing bacteria and reducing mold.

d. Lethal Dosage:

General Electric used colon bacilli to measure the killing power of their lamp and found that this dosage was approximately 6600 microwatt seconds of 2537 energy per square centimeter covered. It seemed to make little difference whether a long exposure of low intensity or a

short exposure of high intensity was used. Exposures ranging in lengths from a few seconds close to the lamp to many minutes at distance of several feet have been found necessary with a single lamp without reflection. A difference in exposure time of lethal dosage is necessary with different bacteria, yeasts, and molds.

e. Volume of air per lamp:

In the General Electric test with colon bacilli, at a medium humidity, one 15-W lamp in a duct made of non-reflecting material, easily sterilized 200 cubic feet of air. It was found, however, that if that duct was made of good reflecting material at 2537 radiation, the ultra-violet intensity was increased considerably expanding correspondingly the volume of air that could be sterilized.

f. Depreciation:

General Electric Company claims that the ultra-violet output of the 15-W lamp is approximately 80 per cent of the initial efficiency after burning 1000 hours. (Germicidal Lamp.) Westinghouse states that their lamp will burn continuously for six months or approximately 4500 hours intermittently. The lamp does not burn out during this time but does lose some of its efficiency. Both of these lamps will emit a perceptible amount of illumination.

g. Effects on Man:

(a) Ozone: Even though ozone is produced in a small amount under ordinary conditions of use by this lamp, it is not enough to be objectionable. Although it is well to remember that ozone can be tolerated by human beings in very limited amounts without becoming irritating to the nose and throat.

(b) Skin: Too long exposure may cause burning of the skin.

(c) Eyes: Direct long exposure will produce a severe conjunctivitis. Short exposure does not appear to have any effect in this respect. Where such lamps are in continual use, a plastic eye shade or ordinary glasses should be worn as an added protection.

h. Effects on Animals:

Poultry and cows suffer many diseases and their transmission presents many problems not entirely dissimilar to those of humans. Spread of bacteria through air and water is as much of a hazard in raising turkeys, for instance, as in maintaining the health of children.

3. INSTALLATION

In offices, schools, factory buildings and all other places people frequent, the lamp should be installed above eye level and fully shielded to exclude direct radiation to the eye. Where it is installed below eye level, as in restaurants, bars, etc., care should be taken to guard against

reflection. Data on the reflective properties of wall paper and paint should be obtained before installation to guard against excessive reflection. It is well to remember that close, direct irridation on wall paper and paint will cause bleaching.

Air changes per hour is the term used in calculating installation of such lamps. This means the equivalent number of room-air-displacements by fresh air. Air circulation within the room greatly increases the effectiveness of such radiation.

Such circulation is facilitated in our homes and factories where cold windows and hot radiators increase the circulation in winter time. This is a fortunate condition since this is generally the season of the year when greater air disinfection is needed.

Exact data relative to the number of units needed per square foot of room area can be obtained from the manufacturers of these lamps, or by consulting your local power company.

4. MAINTENANCE

Proper cleaning of lamps and reflectors is necessary periodically to insure top efficiency. Replacement of the lamp after the period of use as specified by the manufacturer, is also indicated.

5. USES

There are over 150 known applications. A few of the common ones are:

(a) Schools, hospitals, etc.
(b) Industries
    1. Baking
    2. Meat industry
    3. Milk industry
    4. Soft drink industry
    5. Cheese industry
    6. Brewing industry
    7. Cosmetic industry
    8. Farms
    9. Sterilization and storage of eating and drinking vessels.

It is not possible to list or describe all of the possible uses of this lamp, but if contamination due to air-borne bacteria or mold is a problem, the use of such radiation may be the most practical way to improve the product, reduce waste and spoilage, lower operating costs and increase worker efficiency.

Each application requires individual analysis for the most efficient

control of bacteria and mold. The applications generally fall into the following groups:

1. General room sanitization, to reduce mold and bacteria in the air by irradiating the entire room.

2. Localized sanitization, applied directly over work centers, machines and conveyors. In many cases, these lamps are mounted on the machines or conveyors, with hoods which concentrate the radiations in the desired vital areas.

3. In air conditioning ducts the lamps are an unsurpassed means of maintaining sanitary air conditions throughout the plant. Here these lamps will assist in the sterilization of the product, for controlling the spread of contamination between employees and product and for maintaining employees' health.

ABSTRACTS

PERSONALITY PATTERNS IN OCULAR DISCOMFORT. Wayne W. Wong. Archives of Ophthalmology. 42. 4. 443-450. 1949.

Emotional upsets for example, from a new job or a love affair, may cause ocular symptoms such as photophobia, asthenopia, and inability to use the eyes for close work. These are characteristic symptoms of ocular neurosis even though they may be due also to uncorrected ametropia and, or heterophoria.

To distinguish those suffering from *ocular* neurosis, the author states: "Such patients tend to be of a definite physical type. Women predominate over men. In general, these patients are slenderly built. They dress neatly and well despite their actual economic station. Their habits and actions are orderly and well planned. They are endowed with a great deal of energy and 'push' and appear tireless in their pursuit of the goal that 'everything be just so.'

"This inflexibility reflects itself in their actions and thinking. Rather than adapt themselves to a difficult situation in life, they resist and balk, at the expense of their emotional system.

"These patients usually have a low refractive error. They will be found to be hypermetropic. Their visual acuity is 20/20 without glasses. Lenses give only temporary relief, after which the patient feels better without them."

Dr. Wong's study indicates that many people may be wearing glasses unnecessarily and actually need treatment for the underlying emotional cause of their visual disturbances. A study of one thousand consecutive single vision prescriptions in one community indicated that approximately 20 per cent of the lenses were worn by patients "whose benefit cannot be attributed to the optical effect of the lenses alone."

The author concludes that "Persons with ocular discomfort of nonorganic nature have personality characteristics of a definite pattern. Relief of their symptoms consists in helping them to understand their emotional background and directing their energies into less conflicting channels."

R. E. B.

ORTHOPTIC TRAINING IN CONVERGENCE DEFICIENCY UNCOVERS LATENT VERTICAL IMBALANCE— A CASE REPORT*

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CASE HISTORY

This patient, a high school senior, age 20, was referred by his reading counselor because the counselor believed the patient's eyes did not work together. The patient was a retarded reader and has worn lenses since childhood. There was no complaint of visual discomfort or ocular symptoms. The patient was wearing O. D. —0.75 D. sph. O. S. —1.75 D. sph. This correction enabled the patient to have 20/20 distance visual acuity O. D., O. S., or O. U. The first suspicion of an ocular problem came as result of a telebinocular school survey which indicated poor fusion and exophoria.

The patient is tall, slight, and not too robust appearing. He reports good health. However, there was an appendectomy only a month ago from which the recovery has been normal. There was no history of severe or unusual childhood diseases. There is no unusual family history of pathology and the patient's teeth, tonsils and sinuses are normal. The patient's social adjustment and school activities are normal except for athletic participation. School work is unsatisfactory due to the reading problem. The patient's I. Q. was reported quite satisfactory.

PRELIMINARY FINDINGS

The patient's lids, sclera and cornea are normal. Versions and rotations are smooth and ample. His visual axes converge to 2 inches from the bridge of the nose and his pupillary reflexes are quick and adequate.

OPHTHALMOSCOPY AND FIELDS

His media are clear. The eye grounds are normal and rather heavily pigmented. Vessels are normal as to size, ratio and color. The disc is clear, well defined and slightly cupped.

The patient's form fields are ample, blind spots normal as to size, shape and placing.

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ANALYTICAL EXAMINATION (August 9, 1949)

Visual acuity, corrected, O. D. 20/20. O. S. 20/20.

Ophthalmometry,

O. D. 41 D. —0.75 axis 160.
O. S. 41 D. —1.00 axis 10.

Retinoscopy,

O. D. —0.75 D. sph. ⊂ —0.50 D. cyl. axis 110.
O. S. —2.00 D. sph. ⊂ —0.25 D. cyl. axis 80.

Subjective,

O. D. —0.50 D. sph. ⊂ —0.25 D. cyl. axis 120.
V. A. = 20/20.
O. S. —1.75 D. sph. V. A. = 20/20.

Phorias at 6 M. Vertical O. Lateral 1△ exophoria.

Phorias at 40 cm. 11△ exophoria.

Binocular cross cylinder, Add +1.00 D. to subjective. (Gross finding).

Induced phoria, 13△ exophoria.

Negative relative accommodation, +2.00.

Positive relative accommodation, —3.00.

Total amplitude of accommodation, O. D. 10 D., O. S. 10 D., O. U. 10 D.

Relative convergence, Negative, x/24/18. Positive, x/20/16.

Fusion, using the following Keystone cards, DB 8, DB 9, DB 6 D, and A N. 56, normal. Stereopsis normal and vertical balance normal.

ORTHOPTICS

The subjective finding was prescribed for constant wear. This was centered slightly out beyond the distance interpupillary width, to afford a small amount of base-in prism at distance and slightly more when the patient was doing near point work. This was done both in the interest of inducing relaxation in myopia (the distance subjective finding was recorded as given above at 20/20, though the addition of —0.25 D. sph., gave one more line on the chart) and to partially compensate for the high exophoria.

Convergence training was instituted on the Brock stereomotivator with Keystone overhead projector using a large plastic intermediary translucent screen. Fusion was very difficult, and stereopsis practically impossible at less than 6 to 8 feet. Training was transferred to the roto-

scope, using simple first degree targets with red and green color fusion backgrounds with rotation, and a vertical imbalance began to become manifest.

After several training periods, the patient was re-examined (August 30) and 1△ right hyperphoria with vertical ductions of 2/3 was determined. On the rotoscope the vertical phoria measured 2△ of right hyperphoria.

A pair of fit-over spectacles were made up plano ⌒ with 1½△ of vertical prism. This was prescribed for constant wear. With these over his correction, fusion and stereopsis immediately improved using the Brock technique, and digit span on the tachistiscope increased from five to seven at 1/10 second. Rapidity of accommodative rock also increased materially. The Keystone line-and-dot vertical phoria card which had first shown vertical balance normal, now showed the dot entirely below the line, indicating a significant right hyperphoria.

On September 7, a re-examination indicated that the patient's visual acuity had increased to 20/15 O. U. The patient had 2△ of right hyperopia on the rotoscope and by rotary prism measurement, vertical ductions of 1/4. Two degrees of vertical prism were incorporated in the lens correction and the fit-overs discarded.

Through the new correction the distance vertical phoria is now zero, and the lateral ductions are 7/5 negative, and x/16 x/10 positive. The near phoria is from 7△ to 9△ of exophoria, with a positive reserve of 20/24/18. Visual rate and span and general reading have improved materially. The patient is now a freshman in college and doing very well.

DIAGNOSIS AND TREATMENT

This is a report of a case seen with increasing frequency. It is the type of case where orthoptic training uncovers latent tension not apparent during the refraction. On this occasion it was a vertical imbalance which was not evident on any of the standard tests and probably had never been, inasmuch as the patient had had no vertical prism in prior corrections. It was necessary to keep the lens correction current with orthoptic manifestation by using temporary fit-overs during the period of change and later by incorporating the vertical prisms in the permanent correction.

The case was diagnosed as convergence deficiency. An additional problem developed, this being a vertical imbalance which when corrected allowed for the ready correction of the convergence and reading difficulties.

SUMMARY

This is a reading problem case, referred by his reading counselor, as he does not think the patient's eyes work well together. Orthoptic training was instituted for deficient convergence, but the patient soon demonstrated a rather high latent vertical imbalance, not in evidence before. This vertical imbalance was corrected in the lens prescription, the lateral phoria reduced and the reading ability of the patient materially improved.

74 SOUTH THIRD STREET
COLUMBUS, OHIO

ABSTRACTS

THE SPHERICAL ABERRATION OF THE EYE. M. Koomen, R. Tousey and R. Scolnik. Journal of the Optical Society of America. 39. 5. 370-376. 1949.

In connection with experimental work on night myopia, the authors measured the spherical aberration of their own eyes. Various centered annular apertures were placed over the eye pupil and the optimum spectacle correction for each zone was determined. The test object was a "double star" with the separation slightly greater than the minimum resolvable. An ingenious reflecting system used in conjunction with an additive phoropter enabled control of accommodation.

The three eyes that were tested exhibited positive (undercorrected) spherical aberration. In other words, the eyes were relatively more myopic for annular zones farther from the center of the pupil, to an extent of 2 diopters in one case, at the pupil margin. Increasing accommodation was found to reduce the spherical aberration, and, in one case, under high accommodation, the spherical aberration became negative. Homatropine reduced the positive spherical aberration in two of the eyes examined, but failed to change the aberration curve of the third, merely shifting it in the direction of hyperopia.

A very interesting historical section is included in this paper, discussing aberration measurements made as long ago as 1801, by Thomas Young. The majority of eyes tested by various investigators has shown positive spherical aberration, but the magnitudes of the effect vary widely according to the technique used. The authors report a close relation between night myopia and spherical aberration measured by their method, which they hope to present in a future paper.

BERNARD ROSETT

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OPTOMETRY'S ROLE IN A WORLD CRISIS

While the American Optometric Association was in session at Minneapolis, the full impact of the Russian dictatorship's invasion of South Korea became known. At the annual banquet Congressman A. L. Miller (R. Neb.), as speaker ignored in large part his prepared technical address and like his colleague, Congressman Walter H. Judd (R. Minn.), dwelt on the serious international situation facing this country. The prospect of global war was the only note which marred the otherwise excellent 53rd annual meeting of the A. O. A.

This page goes to press before it is known whether the Communist forces will localize their present efforts in Korea, or whether the present Korean struggle will precipitate a war to the death between the free world and the forces of the Kremlin.

If the Communists are determined to fight the Western democracies and their allies, the present crisis may reveal such plans. If the Kremlin is committed to such a course, we are all better off in knowing it at once. Should Communist leadership not care to take the risk of a full-fledged shooting war, the Western democracies collective resistance to Soviet aggression in Korea may now prevent the possibility of a full dress global conflict in the future.

And what of optometry in this crisis. In 1950, the place of the optometrist in the armed services is properly defined. Unlike 1941-45, no faulty tables of organization will lose the identity and skills of optometry as the military forces expand. Today we find the specialized service corps ready to use optometrists as professional men in their capacity of commissioned visual specialists. As a group, optometrists will serve their country in their proper professional capacities.

And as optometrists, too, we must face up to this situation—that as members of the Western democracies we are engaged in a fight for survival. Whether on a cold war basis or a shooting one, the pressure by the Kremlin continues and until there is a reversal in Russian thinking and planning, we must expect this international discord to continue. It is only by presenting a constantly determined and united front against Communism that a lasting peace can become possible.

CAREL C. KOCH.

A. O. A. CODE OF PRACTICE—A FORWARD STEP

Another forward step has been taken in the important work of clarifying practice standards for optometry. At the 53rd annual Congress of the American Optometric Association, the House of Delegates approved the following code of practice, which, when ratified by the constituent state organizations, will unequivocably place the A. O. A. in a position to demand proper standards of practice from all member optometrists.

No member shall wilfully violate the optometry law or the optometry board rulings of the state in which he practices.

No member shall practice in or on premises where any materials other than those necessary to render his professional services are dispensed to the public.

No member when using the doctor title shall qualify it in any other way than by the use of the word "optometrist." He may, however, when not using the prefix, use after his name the "O.D." degree designation.

No member actively engaged in the practice of optometry shall in any manner publicize or hold himself forth as an optician.

No member shall display his license, diplomas, or certificates in such manner as to be seen and read from outside his office.

No member shall hold himself forth in such a way as to carry the slightest intimation of having superior qualifications or being superior to other optometrists.

No member holding an official position in any optometric organization shall use such position for advertising purposes or for self-aggrandizement.

No member shall display any sign containing other than name, profession, and office hours; same to be used only on office windows or at entrance to his office. Letters must not be luminous or illuminated, and must not be more than 4″ in height for street level and 7″ in height for offices above street level.

No member shall display eyeglass signs or painted or decalcomania eyes anywhere.

No member shall use other than his professional card on or in any publication or in any public display; said card shall not exceed two (2) columns by two (2) inches, and it shall not contain any more than his name, profession, address, telephone number, office hours, eye examinations by appointment, practice limited to any *one* optometric specialty. Educational material may be published only when it has been specifically approved by the executive committee of the respective state association.

No member shall use bold-face type or in any other manner attempt to attract special attention to himself in any telephone or other public directory.

No member shall display any merchandise, ophthalmic material or advertising of any kind in windows or in any room of his office for the purpose of inducing patronage.

No member shall do anything inconsistent with professional standards of the optometric and allied health professions.

No member shall fail to observe scrupulously the code of ethics and other provisions of both his own state association and the American Optometric Association.

This action on the part of the A. O. A. has been long in coming. The newly adopted code of practice, coupled with the already approved A. O. A. code of ethics now places organized optometry squarely along side of those professions which refuse to temporize with bad taste in practice procedure and violations of normal ethical concepts as these apply to professional careers. The American Academy of Optometry welcomes this step on the part of the A. O. A. and joins that body in urging immediate state ratification of this important code.

CAREL C. KOCH.

NEW OPHTHALMOLOGICAL RESOLUTION ADOPTED BY A. M. A.

On June 27, 1950, the American Medical Association, house of delegates at San Francisco, California, approved the following resolution as originally submitted by Dr. Judd S. Beach.

That the section on ophthalmology of the American Medical Association declares that it is entirely within the definition of medical ethics for its members to engage in lectures, demonstrations, the preparation of pamphlets and other measures suitable for the dissemination of information designed to prevent blindness and directed to any non-medical group.

This official action annuls or supersedes the 1935 anti-optometric resolution of this body, thus removing one major obstacle which stood in the way of closer cooperation between optometry and ophthalmology. Optometry welcomes this progressive step on the part of organized medicine.

CAREL C. KOCH

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items for general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

A. O. A. CONGRESS CLICKS

"A success on all scores" is the label put on the 53rd annual Congress of the American Optometric Association by the more than 1,000 optometrists and their guests who attended. The Minneapolis weatherman was on his best behavior (no snow or rain), assuring the success of bus trips, and the outdoor smorgasbord. The educational programs were well attended. A new code of practice was adopted which will help push optometry even further ahead professionally. The Scandinavian strollers, Gay Nineties quartet, Aquatennial singers, and the many other entertainers put on outstanding performances. The exhibits were superb.

This reporter circulated a great deal during the convention and heard nothing but praise, and that's something when you're trying to please more than 1,000 people at the same time.

Dr. J. Ottis White, Baton Rouge, Louisiana, was elected president of the A. O. A. at the closing business session of the Congress.

Dr. James F. Wahl, Anna, Illinois, was named to the post of first vice president vacated by Dr. White. Former trustee Dr. Lawrence H. Foster, San Jose, California, was elected second vice president; Dr. Joseph M. Babcock, Portsmouth, Ohio, third vice president; Dr. Norman B. Hays, Niagara Falls, New York, fourth vice president. Dr. John B. O'Shea, Northampton, Massachusetts, retiring president, was named trustee.

Re-elected to office were Dr. S. L. Brown, Fostoria, Ohio, treasurer, and Dr. Ernest Kiekenapp, Minneapolis, Minnesota, secretary.

New Orleans, Louisiana, was selected as the 1951 Congress city.

Ten outstanding authorities on visual problems participated in the educational side of the Congress program. On Sunday afternoon, a panel on remedial reading problems was held at the Nicollet Hotel. Special guests were educators from the Midwest area. Dr. Guy Bond, professor of education at the University of Minnesota spoke on the educator's approach. Mrs. Dorothy Nicolas, senior counselor at Minnesota, covered the student counselor's approach; Dr. G. N. Getman, assistant to Arnold Gessell, child development clinic, Yale University,

the developmental approach, and Dr. Marguerite Thoma Eberl, chairman of the A. O. A. committee on visual problems in schools, the clinician's approach. Dr. H. C. Sherratt of Minneapolis was panel moderator.

Other speakers at the Congress were Dr. Richard Feinberg, dean, Pacific University School of Optometry; Dr. Eugene Freeman, dean, Chicago College of Optometry; Dr. Henry Hofstetter, dean, Los Angeles College of Optometry; Dr. Thaddeus R. Murroughs, Chicago College of Optometry, and Dr. Otis R. Wolfe, Marshalltown, Iowa.

Guests speakers of the A. O. A. at the annual banquet were Dr. Walter H. Judd, Republican representative from Minnesota, and Dr. A. L. Miller, Republican representative from Nebraska.

Before introducing Congressman Miller, the main speaker of the evening, Dr. Judd spoke briefly of the role optometrists must play in the complex world of today.

"More optometrists should get into politics," declared Dr. Judd to the more than 1,000 optometrists and guests who filled the Radisson main ballroom to overflowing.

"The scientific and objective mind is needed desperately today in our country," he went on. "America is the hope of the world, and I pray we can fulfill that hope."

Dr. Miller praised optometry for its "enormous strides" but reminded his audience that a great deal of progress still must be made.

"Top service is always necessary to gain complete confidence of the public," he said.

The Congressman urged the profession to build a "good bridge" for young optometrists to cross, and to keep our democracy great through continued building of good character.

"Don't forget optometry is part of the drama of progress in the world today," said Dr. Miller.

Both Congressmen were practicing physicians before entering politics.

BETA SIGMA KAPPA AWARDS TWO GOLD MEDALS

Beta Sigma Kappa, national optometric fraternity, at a special luncheon meeting during the recent A. O. A. Congress, presented honorary gold medal awards to Dr. Ernest H. Kiekenapp and Dr. Carel C. Koch, both of Minneapolis, for distinguished service to optometry.

The awards were presented on behalf of the fraternity by Dr. William van Essen—to Dr. Kiekenapp for 29 years of outstanding service to optometry as secretary of the A. O. A., and to Dr. Koch for

his 27 years of editorship of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

Dr. Harry Pine, national president of Beta Sigma Kappa, presided at the meeting.

QUESTIONS ON TELEVISION

Ohio State's Institute for Research in Vision is currently surveying Ohio eye specialists on their experience with patients who watch television. The questionnaire recently sent out to 2,500 doctors has a threefold purpose: (1) To discover whether there has been a noticeable increase in patient calls due to television. (2) Whether findings indicate television is directly responsible for visual difficulties. (3) Whether special glasses are required for television viewing and if so, what prescription is recommended.

The practitioners have also been asked what they believe are the ideal conditions for viewing television with a minimum of eye strain and eye fatigue.

Findings on the survey will be made public as soon as questionnaire returns are analyzed. Dr. Glenn A. Fry, director of the Ohio State University School of Optometry, and Dr. Arthur M. Culler are co-directors of the institute.

NEW FILM, "WONDERLAND OF VISION," RELEASED

Sidelights to remember when watching the Better Vision Institute's new educational color film, "The Wonderland of Vision": Westbrook van Voorhies, the narrator, has been the Voice of Time for years. Five "shooting" locations were required during the six months of production to cover the various aspects of the story. The film cost several thousand dollars.

Premiere of the film took place at the annual B. V. I. meeting in New York recently. The two-reel, 20 minute film, describes the eye and its functions: processes of ophthalmic glass manufacture; lens processing, examining and dispensing skills. Fashions in eye wear complete the picture.

"Wonderland of Vision" is a B. V. I. educational project for consumer consumption.

VISUAL TRAINING WORKSHOP AT SAN JOSE

San Jose's seventh annual visual training workshop will get under way Saturday, August 19th, and continue through the 20th. Dr. Sol K. Lesser, Fort Worth, will head the roster of speakers, which also includes Dr. A. M. Skeffington and Dr. Joseph B. Cooper, professor of psychology at San Jose State College. Clinic tables will be supervised

as follows: reading problems from the optometric viewpoint—Dr. James W. Gregg; fusion training—Dr. E. F. Richardson, Sr.; home training techniques—Dr. Charles F. Brooks; effective and inexpensive training devices—Drs. W. P. Campbell and Seymour Galina.

Optometrists planning to attend from outside California may contact Dr. Goodloe Gilmer, Suite 410, Sainte Claire Building, San Jose, for information and reservations.

ALABAMA VISUAL PANEL HELD

A physicist, an ophthalmologist and an optometrist lectured at the recent educational seminar of the Alabama Optometric Association in Montgomery, June 4.

Dr. E. Scott Barr, Tuscaloosa, physicist of the University of Alabama, spoke on "Properties and Uses of Infra-Red and Ultra-Violet Light."

Ophthalmologist David A. McCoy of Birmingham presented a paper on glaucoma, and Dr. Donald A. Springer, optometrist from Anniston, discussed public relations in optometry.

JOURNALS CHANGE NAMES

Two major magazines of interest to optometry have undergone publishing changes recently.

The *Quarterly Review of Ophthalmology and Allied Sciences* has now been combined with the *Quarterly Review of Otorhinolaryngology and Broncho-Esophagology*. The March, 1950, issue was published as the *Quarterly Review of Ophthalmology and Otorhinolaryngology*. This abstract quarterly is published by the Washington Institute of Medicine. Dr. Julius Neumueller of Haddonfield, New Jersey, has been added to the editorial board of the new journal, he being the fifth optometrist on the board. The others are, Dr. Robert E. Bannon, Dr. Glenn A. Fry, Dr. K. B. Stoddard and Dr. C. L. Treleaven.

The *British Journal of Physiological Optics* is out with a revised name and a new dress. The publication was called the *Dioptric Review and British Journal of Physiological Optics*. A new cover adds to the attractiveness of the current issue. The well known British optometrist, H. B. Martin, is chairman of the editorial board, assisted by M. Cholerton, G. W. Colebrook and J. Cowan Meadley. This British technical journal is published quarterly under the editorial supervision of G. H. Giles, secretary, British Optical Association, 65 Brook Street, London, W. 1. The April, 1950, issue contains five original papers, book reviews and abstracts. Readers in Canada and the United States

may subscribe by sending a foreign money order in the amount of $5.00 to the British Optical Association.

LOS ANGELES COLLEGE OF OPTOMETRY GRADUATE SUMMER COURSE

Advance notice of an intensive four-week course in postgraduate optometric subjects comes from Los Angeles College of Optometry. Starting August 7th, courses will be offered in contact lens fitting, orthoptics, recent trends in physiological optics, ophthalmic dispensing, clinical analysis and visual school survey technique. Optometrists may enroll for one or more weeks. Lecturers signed up to date include Drs. Wilma Baber, Solon Braff, Margaret S. Dowaliby, Edward I. Goodlaw, Robert Graham, Monroe Hirsch, Henry Hofstetter, Henry A. Knoll, Kevin Tuohy and Gordon L. Walls. Recreation and social events are being planned for enrollees. Further information is available from Dr. Monroe J. Hirsch, Los Angeles College of Optometry, 950 West Jefferson Boulevard, Los Angeles 7.

NEWS BRIEFS

Canadian optometrists will get together June 10, 11, 12, 1951, for their All Canada Congress. Invitations are already out. Winnipeg, Manitoba, is the Congress city; E. I. Cummings of the Manitoba Optometric Society (Box 266, Winnipeg) the man to contact for more information. . . . Doctor of Optometry degrees were conferred on 77 candidates at Southern College of Optometry in June. The commencement address was given by Daniel Rashall, public relations counsel of Memphis. . . . Dr. Joseph Pascal is representing the New York Society for Clinical Ophthalmology this month at the sixteenth international congress of ophthalmology in London, England. Dr. Pascal is presenting a scientific exhibit on a "Graphic Study of the Ocular Muscles." . . . A special campaign against trachoma will be waged by the World Health Organization in 1951. The decision to expand research in this field was made at the recent third world health assembly in Geneva, Switzerland. Delegates and observers from 63 countries and territories were at the meeting. . . . A national educational campaign designed to justify to the public the cost of professional service is under way by the American Optical Company. Messages in the new drive are currently appearing in major national magazines. . . . Roy Marks, formerly sales manager at Bay State Optical Company, has now joined Bausch and Lomb Optical Company's sales division. . . . The 1950-1951 estimate of the total cost for compulsory health insurance to the taxpayers of England is £450,000,000. According to the *Dioptric News*, issue of March 17, 1950, about £25,100,000 of this will be

needed for sight testing and spectacles. To assist in keeping this tax burden from rising even higher the governmental health authorities have now removed all of the modern improved ophthalmic frames from the "free" [?] list. British patients wanting these better frames through the compulsory health insurance program must now pay from 2*s* to 12*s* each towards their cost.

BOOK NOTICES

THE EYE AND ITS DISEASES. By 92 International Authorities: Edited by Conrad Berens, M.D. Second edition 1949. Published by the W. B. Saunders Co., West Washington Square, Philadelphia, Pa. 1,092 pages. 436 illustrations. 8 color plates. Cloth. $16.00.

The first edition of *The Eye and Its Diseases*, published in 1936, earned the approval of the ophthalmic professions and provided at that time the latest authoritative information on the eye and its anomalies. Now, thirteen years later, the second edition of this book is available. It adheres to the outline of the first edition as far as possible and new chapters on illumination, physiologic chemistry and gonioscopy have been added.

The inclusion of many new illustrations which are unusually well done is a helpful feature. Each contributor has revised his section and in most instances the bibliographies have been brought up to date. The masterful treatment of the various sections by distinguished authorities greatly enhances the value of the book.

The general appearance of this second edition is different from the first by the introduction of double column printing which gives it a more pleasing appearance and makes for easier reading. Recent advances in therapeutics and in the knowledge about eye diseases have been reviewed thoroughly and careful selection made of the material included in the book.

Many factors contribute to recommend this book highly to students and instructors. The material presented and the comprehensive index make an invaluable reference work for all those interested in authoritative information on present-day concepts of the eye and its diseases.

Following the introduction, a history of ophthalmology, by Thomas Hall Shastid, there are 14 general sections each divided into chapters. Section I deals with embryology, anatomy and postnatal development of the eye. Section II deals with physiology and physiologic optics. In this section is the new chapter on light and lighting by

Walter B. Lancaster. Optometrists will find that this section is of particular interest. Section III is devoted to "Examination of the Eye" and includes chapters on visual acuity, ophthalmoscopy, tonometry, peripheral vision and perimetry, etc. This is another chapter of interest to the optometrist. However, of still greater interest is Section IV on "Refraction and Accommodation" including chapters on the etiology and symptomatology of refractive errors, aniseikonia and anomalies on accommodation. Of course, the book is not a textbook on refraction but rather on ocular diseases and this section occupying only 57 pages is greatly condensed. Much worthwhile material and many recent advances in refractive technique are not included.

Section V, consisting of 359 pages, presents quite extensively the significant knowledge of the authors on "Diseases of the Eye" including chapters on general pathology, diseases of the orbit, lacrimal apparatus, eyelids, conjunctiva, cornea, sclera, etc. Trachoma, glaucoma, sympathetic ophthalmitis and toxic amblyopia are intelligently discussed in the light of the most recent advances in ophthalmology.

Section VI deals with medical ophthalmology. Section VII is concerned with movements of the eyeballs and their anomalies. There is a short chapter on orthoptic training by M. A. Pugh.

Injuries of the eye is covered by section VIII and the eye and the nervous system is the subject matter of section IX. Section X is devoted to treatment: general and local treatments, surgery of the eye and its adnexa.

Section XI on preventive ophthalmology, section XII on immunology, section XIII on legal aspects of ophthalmology and section XIV on laboratory techniques, complete the volume with the addition of the extensive and carefully prepared index.

This book may well be considered the condensed (American) Bible on the eye and its diseases. It covers the essential material on the eye and its anomalies in light of the best up-to-date knowledge and it provides a reference source that will be of great value to any student, teacher or practitioner interested in the eyes and their care.

ROBERT E. BANNON